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SMALL SEWAGE TREATMENT SYSTEMS. EXPERIENCE AND COST DATA IN 61 SUB-DIVISIONS IN 12 STATES

NAHB Research Foundation, Incorporated
Rockville, Maryland

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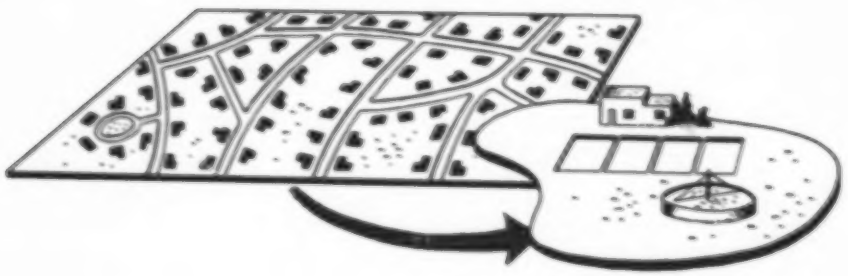

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FOREWORD

Provision of adequate facilities for the disposal of household waste is becoming increasingly difficult. Land for new housing is available only farther and farther from the central city. Central city sewerage facilities are operating at or near capacity. It is becoming less and less economically feasible to extend sewers into outlying areas. This is particularly true for the kind of housing that average income American families can afford to buy or rent. Furthermore, the large number of overlapping local and governmental jurisdictions with conflicting regulations and practices all too often effectively prevent such extensions.

The demand for new housing is the direct result of the rapid increase in our population and new family formation. Many metropolitan areas as well as smaller communities lack adequate legal authority and financial capacity to provide public sewerage or water systems to accommodate the increased population. If good housing is to be available to all American families, all possible methods of solving any problem that hampers housing construction must be explored.

The objective of the NAHB Research Institute is to assist the home building industry to produce better homes at a lower cost. One of the methods by which the Research Institute attempts to accomplish this is to prepare and make available accredited information on the many facets of the home building process to all segments of the industry.

Accordingly, I am especially pleased to commend this booklet on community sewage treatment systems to home builders, engineers, architects and city planners as a contribution toward this goal.

CARL T. MITNICK
President
National Association of
Home Builders

PREFACE

Several systems are available for the disposal of household wastes, a problem that is inherent in the building of homes. One of these is the so-called "community" or small sewage treatment plant. The purpose of this booklet is to describe some of the "community" sewage treatment systems that are in use and to provide data on their construction and operating costs. These systems have proven to be practical and satisfactory. However, these systems are not necessarily recommended in preference to others. They were selected as representative of the typical systems now in use.

It is recognized that planning and design practices, construction problems, climate, land use, stream requirements and soil conditions have an important bearing on the selection of the type of sewerage system. This booklet is not intended to be a design manual, since compliance with local requirements and regulations is a specific problem in engineering design.

It should be recognized that some of the sewerage systems described here may not be fully in accordance with the requirements of all *other* governmental health agencies and all local offices of the Federal Housing Administration or the Veterans Administration.

Grateful acknowledgment is extended to the following people for valuable assistance furnished in the planning and preparation of this publication: Messrs. Maurice LeBosquet, Jr., Malcolm C. Hope, and Paul W. Richards, Public Health Service, U. S. Department of Health, Education and Welfare; Mr. James R. Simpson, Federal Housing Administration; the State Health departments of the twelve States included in the survey (California, Colorado, Florida, Illinois, Indiana, Kansas, Missouri, New Jersey, New York, Oregon, Texas, and Wisconsin); certain County Engineers of these States; and the home builders, developers, utility companies, and consulting engineers who supplied the information on which a major portion of this publication is based.

RALPH J. JOHNSON
Director
Research Institute
National Association of
Home Builders

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INTRODUCTION

The collection, treatment, and disposal of household wastes in suburban subdivisions have become problems of major concern to the home building industry and to State, county, and city health officials. As our population continues to increase, land in outlying areas must be used for new housing. Since public sewer systems are not always economically feasible or even possible in some areas, other methods of sewage disposal must be utilized if the population is to be housed.

The need for specific cost data as experienced by suburban area land developers has led to a cooperative study of this subject by the National Association of Home Builders Research Institute and the Public Health Service. This study was made in twelve States and covered several geographic regions where extensive land development is taking place. This booklet presents detailed cost data on the installation and operation of public sewers and community sewage treatment plants as experienced by builders of 61 new housing developments in the twelve States surveyed.

The disposal of sanitary wastes by connecting new houses to an existing public sewerage system* that can handle the additional load is usually the best procedure when that is feasible. If sewers are not available and soil and site conditions are favorable for septic tank systems, such systems, properly designed and installed, will give satisfactory service. If it is not feasible to connect to an existing sewerage system, community-type systems with treatment works can be and are being used. Many such successful installations of independent sewer systems and treatment plants in suburban areas were investigated during the survey.

Varying degrees of authority to control the installation and operation of sewage disposal systems are vested in the State boards of health or State water pollution control agencies. Most States prefer to have new homes connected to existing public sewer systems. Some of the States favor community treatment plants in new subdivisions; others have no objections to the use of properly designed septic tanks, and a few States actually prefer them. By and large, each new suburban housing development constitutes a separate case where the solution of the sewage disposal problem depends upon specific local conditions and on the requirements of the State and County.

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* A public system, as referred to in this booklet, is a sewerage system, almost always publicly owned, which serves homes and industries in a municipality. A community system is one that serves a number of homes, as in a subdivision, and may be owned by a municipality, the home owners, or by a privately-owned utility. An individual system is one serving a single home, and generally consists of a septic tank with an accompanying subsurface drainage system.

POLICY

Federal

The sewage disposal requirements for new housing under the programs of the Federal Housing Administration and the Veteran's Administration are essentially the same. Both programs require connection to an existing public sewer system or to a properly designed community sewer system if feasible. If, after a thorough investigation, such a connection is found to be impossible or impracticable, they will then consider the acceptability of individual sewage disposal systems.

To be acceptable to these agencies a community system must comply with all State and local laws and regulations, and be approved by the health authorities. Permanent maintenance and continuous use and operation must also be assured.

State

State policies on sewage disposal requirements, including suburban area systems, vary considerably. Obviously then, land developers should become familiar with the sewage disposal policy of their State, and make sure that the sewage disposal system they are planning will meet with the State's requirements.

Of the 12 State health departments visited in the study, all were of the opinion that the operation and maintenance of community sewerage systems are more satisfactory when under control of some governmental agency, such as a city, town, water control and improvement district, or a sanitary district, as may be provided for in State legislation. This kind of governmental organization is mandatory in 7 of the 12 States visited, although interim operation and maintenance of the facility by a developer or private individual is permitted until such time as the subdivision is completed. In 5 of the States (Colorado, Florida, New Jersey, Oregon, and Texas), the State water pollution control agency approves private operation and maintenance of the system by the developer. In most of the States where private operation is approved, home owners' associations are permitted to operate the system when the developer has completed construction.

Operation of sewerage systems under authority of State Utility Commissions is approved in 6 of the 12 States visited. However, in one State (Wisconsin) the sewerage utility must be operated in conjunction with a water supply service.

COSTS

Cost is an important factor in the development of a community sewerage system. To be practical, the cost of the system should not exceed the combined cost of individual household waste disposal units. Septic tanks installations vary in their cost, depending on several variables such as soil conditions, ground water level, topography, and State and

local requirements. The cost of septic tank systems varies from about $150 to $700 per house. Costs of the various types of sewerage systems studied in the survey are given in Tables 1 and 2, Appendix A.

Community sewerage systems may be designed for any number of houses. Package plants are available in sizes to serve as few as ten houses. Without specific detailed information it is not possible to state the number of houses required to make a community sewerage system economically feasible. In many areas, however, treatment plants for 100 or more houses have been found to be economically feasible.

For example, in Harris County, Texas, one builder installed sewers and built a treatment plant, using metal in lieu of concrete, for a combined cost of $463 per house, based on the first 80 homes connected. The projected cost, based on an ultimate development of 1,000 homes, will be reduced to about $106 per house.

Another builder in Texas, who had completed 15 homes in the "$35,000 and up" price range on half acre lots, stated that it was more economical for him to provide sewers and treatment than to install individual home septic tanks. Based on past experience, he estimated septic tanks, properly installed, would cost from $485 to $525 each, plus the cost of 300 feet of drain tile. The total cost would have been more than the $635 per house which the developer paid for sewers and treatment to serve the 29-home development. The cost of this sewerage system was recovered in the sale price of the house. These properties were sold with conventional financing.

LEGISLATION

Enabling legislation providing for the organization of suburban area sewer districts differs throughout the country. Most States have laws which provide for the establishment of special governmental local entities and give them certain powers to plan, construct, and operate sewerage systems. Some States have statutes relating to the operation of privately-owned utilities, including corporations. In 4 States (Colorado, Illinois, New Jersey, and Texas) such organizations may operate under the authority of State commissions which issue special permits for this purpose.

AESTHETIC CONSIDERATIONS

An important aspect to be considered in design of subdivision sewerage systems is the location of the treatment facility with respect to residences or its proximity to adjacent dwelling units not a part of the immediate area development. During the 12-State survey, the average distance of the treatment facility from the nearest home was observed to be between 400 and 500 feet. The maximum distance noted was over one mile. In five of the 61 installations visited, houses were located at a distance of less than 200 feet from the treatment plant and no untoward effects were noted.

Although sewage treatment plants are potential odor nuisances, careful maintenance will minimize the problem. In the installations visited no noxious odors were detected. Several sewage stabilization ponds (lagoons) were observed in the Kansas City metropolitan area, and these were free from odor. Even the musty or woodsy odor often detected around well-operated conventional secondary sewage treatment facilities was not present.

When planning a sewage treatment plant to be located near a housing development, consideration may be given to landscaping the grounds. The use of trees, shrubs, and flowers will enhance the appearance of the area and tend to conceal the presence of the treatment plant.

WHAT IS SEWAGE TREATMENT?

Sewage treatment is not some sort of mystical or magical process. Adequate sewage facilities merely speed up the forces of nature instead of allowing them to take place gradually over a much longer period. Modern facilities involve the action of gravity in the settling of suspended solids; and the action of bacteria, algae, and other living organisms which act on the organic matter. Sewage treatment separates as much of the suspended solids as possible from the liquid, and both solids and liquids are processed to render them suitable for final disposal. The degree of treatment required varies with the circumstances involved. Such factors as amount of waste, as well as the size, condition, and use of the watercourse to which the effluent will be discharged, determine the degree of treatment which must be provided in each additional case. State, County, and local health departments can materially assist the builder's engineer in planning the treatment plant.

Primary Treatment

When a limited amount of treatment is desired, the sewage is given primary treatment. This consists of separating the floating material, grease, scum, and settleable solids from the liquid, disposal of the separated materials, and discharge of the liquid without further treatment. The separated materials represent about one-half of the organic matter found in household sewage. Some units of the treatment processes which are utilized in primary treatment are sedimentation basins (settling tanks), sludge digestion tanks, sludge drying or disposal facilities, and sometimes chlorination facilities. Often these pieces of equipment are preceded in the treatment plant by a grit chamber and a bar screen or grinder.

The units shown at the left in Figure 1 are usually included in the primary treatment process. Most of the organic material which remains after primary treatment is in a dissolved state. If further treatment is necessary, additional processes known as secondary treatment must be provided.

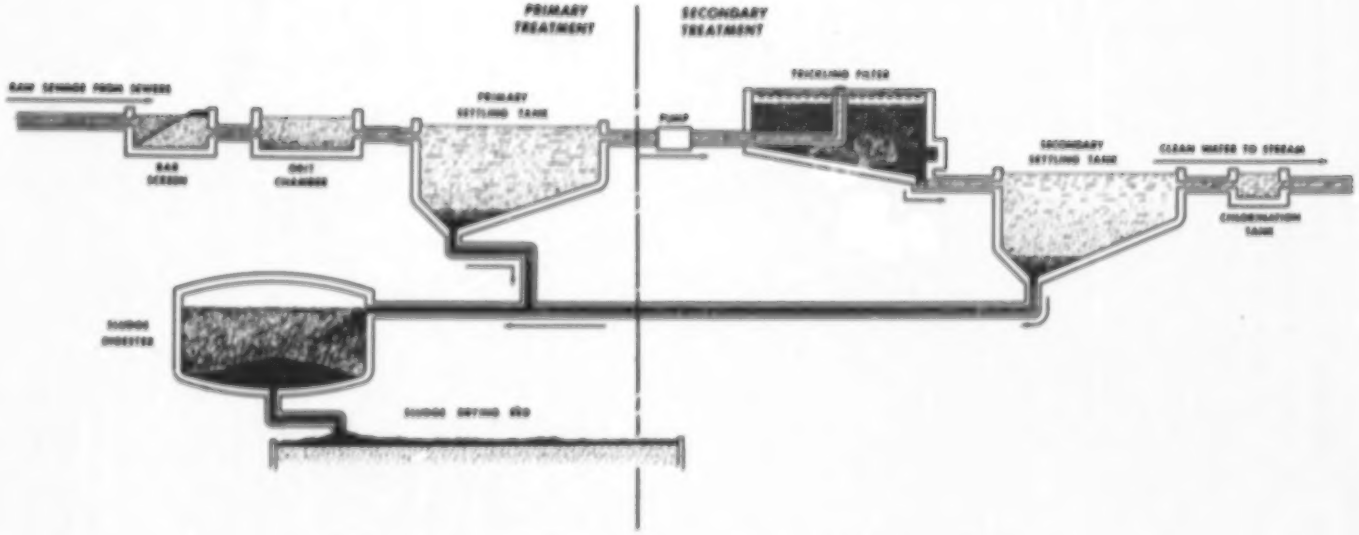


Figure 1 - FLOW DIAGRAM FOR CONVENTIONAL SEWAGE TREATMENT PLANT

Secondary Treatment

Most secondary treatment facilities employ biological processes which, when combined with primary treatment, will produce a treated sewage effluent from which 95% of the organic material has been removed. They include such units as trickling filters, activated sludge tanks, intermittent sand filters, and stabilization ponds. Each of these has its advantages in particular situations, depending upon the various factors involved. Some are more costly than others in original construction cost but less expensive from the standpoint of operation. Construction and operation costs of some secondary plants (excluding waste stabilization ponds) are nearly twice as great as costs for plants providing primary treatment alone.

The units shown at the right in Figure 1 constitute the secondary portion of a complete treatment plant. In the trickling filter, sewage trickles over a bacteria-covered surface and the biological process is expedited by the natural circulation of air through the filter. A drop in elevation of the liquid is required to operate the rotary distributor normally used on a trickling filter, and there is a further drop through the trickling filter itself. The activated sludge process, which is sometimes used in place of the trickling filter, is one in which air is forced through the sewage, thereby agitating it and expediting the biological process. In such an installation, the primary settling tank, sludge digestion tank, and secondary settling tank are all built with practically the same liquid elevation, so there is no appreciable loss in elevation through the process. A stabilization pond is sometimes used instead of the second units mentioned.

Stabilization Ponds

In some States sewage stabilization ponds are used, replacing *all* the conventional treatment plant equipment shown in Figure 1. The stabilization pond, when properly designed, constructed, and used, has proven to be odor free and to produce an effluent equal to, if not better than, that obtained from most other types of treatment facilities. In some areas, such as the southwest and parts of the midwest, the stabilization pond is employed as a permanent facility, and in others it is used as a temporary measure. Construction cost of these ponds, not including land, can be as low as $15 per house without land and the operating cost is negligible except where pumping may be necessary. Most domestic sewage stabilization ponds in the United States are designed on the basis of 30 to 60 houses per acre of pond surface area depending on the design standards of state regulatory agencies and variations in climatic and other conditions. Total land area purchased for these ponds is frequently about twice the pond area required.

Package Units

Several manufacturers of sewage treatment plant equipment supply all the mechanical equipment required for a treatment plant in a "package unit." They manufacture these units in a range of sizes for use in small subdivisions and in moderate-sized cities. Use of these units, often re-

ferred to as "proprietary devices", may result in a saving in construction due to quantity production. Engineers experienced in the design of sewage treatment plants are aware of the advantages and disadvantages of various package plants for a specific design.

Lift Stations

Besides the pumping facilities provided at the treatment plant, sewage lift stations are sometimes required in the sewage collection system. The need for these lift stations depends upon the terrain.

Where sewage collection systems are to be incorporated in a subdivision, the engineer employed to design the treatment facilities should be consulted when the subdivision is being planned and laid out. This early consultation may be the means of eliminating one or more pumping stations, also making it possible for the builder to provide the needed sewage treatment facilities on the most economical basis.

DEGREE OF TREATMENT NEEDED

Many factors must be considered in selecting the type of treatment best suited for a given subdivision. These factors include the size of the population to be served, and the size, condition, and use of the stream into which the effluent of the sewage treatment plant will be discharged. A competent engineer experienced in this field is considered essential to assist in the design of the sewage collection system and the treatment plant.

Governmental agencies, such as the County and local health departments, and the State water pollution control agency, should be consulted by the developer and his consulting engineer as early as possible. If the houses are to be financed under the Federal Housing Administration or the Veteran's Administration programs, these agencies should also be consulted during the early design stage. Determination of the degree of treatment necessary, as well as approval of the plans for the facility, is usually the function of the State water pollution control agency. However, in some cases the County and local health departments may have some responsibilities in these matters. Sometimes the Federal insuring agencies require a higher degree of treatment than do the State and local authorities, particularly when there is a strong possibility that the increased treatment will be necessary within a year or so after completion.

STAGE CONSTRUCTION FOR FLEXIBILITY

In some suburban area developments it may be necessary to plan the sewage treatment facilities so as to provide future additional capacity to allow for growth of the development or for the interception of sewage from adjacent areas. Flexibility can be obtained by planning to build the facility in "stages", both for enlargement and for additional treatment. Flexibility may be the deciding factor as to the economic feasibility of providing a community sewerage system for the subdivision.

Figures 2 and 3 illustrate examples of engineering designs for stage construction. These are only two of the many ingenious designs now in use.

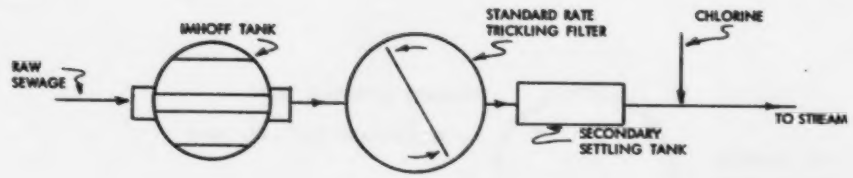
The plan shown in Figure 2 was designed for 125 homes initially, an intermediate need of 250 homes, and an ultimate need of 500 homes. The three stages of construction are shown. The first stage consisted of an Imhoff tank, plus a trickling filter for the ultimate development. Because of the small initial load, the tank designed for ultimate use as a chlorine contact chamber was initially used as a secondary settling tank.

In the second stage, the Imhoff tank was converted to a sludge digester and provisions were made for a combination primary and secondary sedimentation tank. This is indicated on the chart by two half circles. The initial secondary settling tank was converted to a chlorine contact chamber.

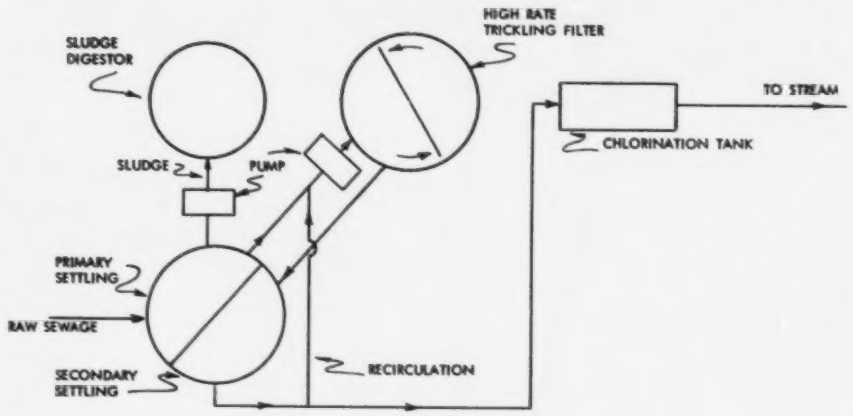
In the final stage, the combination primary-secondary sedimentation tank was converted to a primary clarifier and a separate secondary clarifier was constructed.

Figure 3 indicates the plant components and additions needed in stage construction of a larger development, i.e., 500, 1080, and 2160 homes.

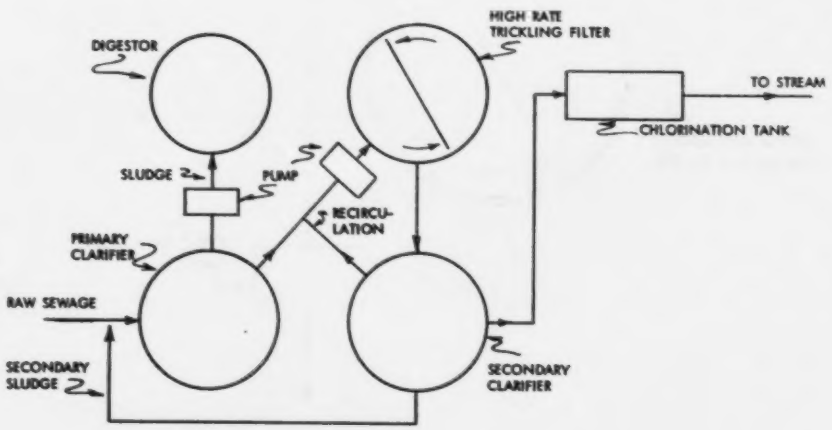
Some State water pollution control agencies approve sewage stabilization ponds. These can also be utilized as temporary treatment facilities during one or more phases of the development. Such ponds have been constructed at a cost as low as about $15 per house without land. When new home construction exceeds the design capacity of these ponds, additional facilities can be constructed for the initial phase of treatment and the ponds can then be used either as secondary treatment units or following secondary treatment where the treated effluent must be of the very highest quality.



STAGE I - 125 Homes



STAGE II - 250 Homes



STAGE III - 500 Homes

Figure 2. DIAGRAMMATIC EXAMPLE OF STAGE CONSTRUCTION FOR 500-HOME DEVELOPMENT

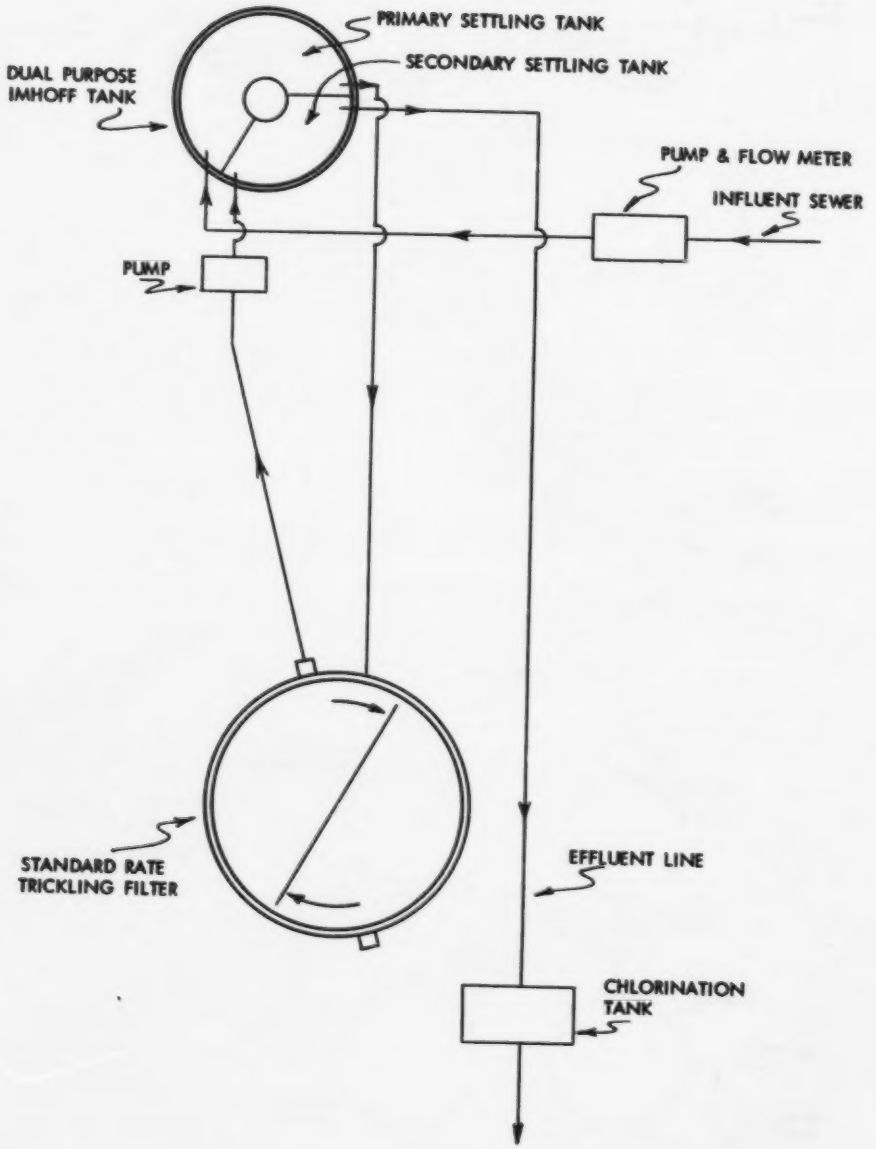


Figure 3 - DIAGRAMMATIC EXAMPLE OF STAGE CONSTRUCTION FOR ULTIMATE 2, 160-HOME DEVELOPMENT
Stage 1 500 homes

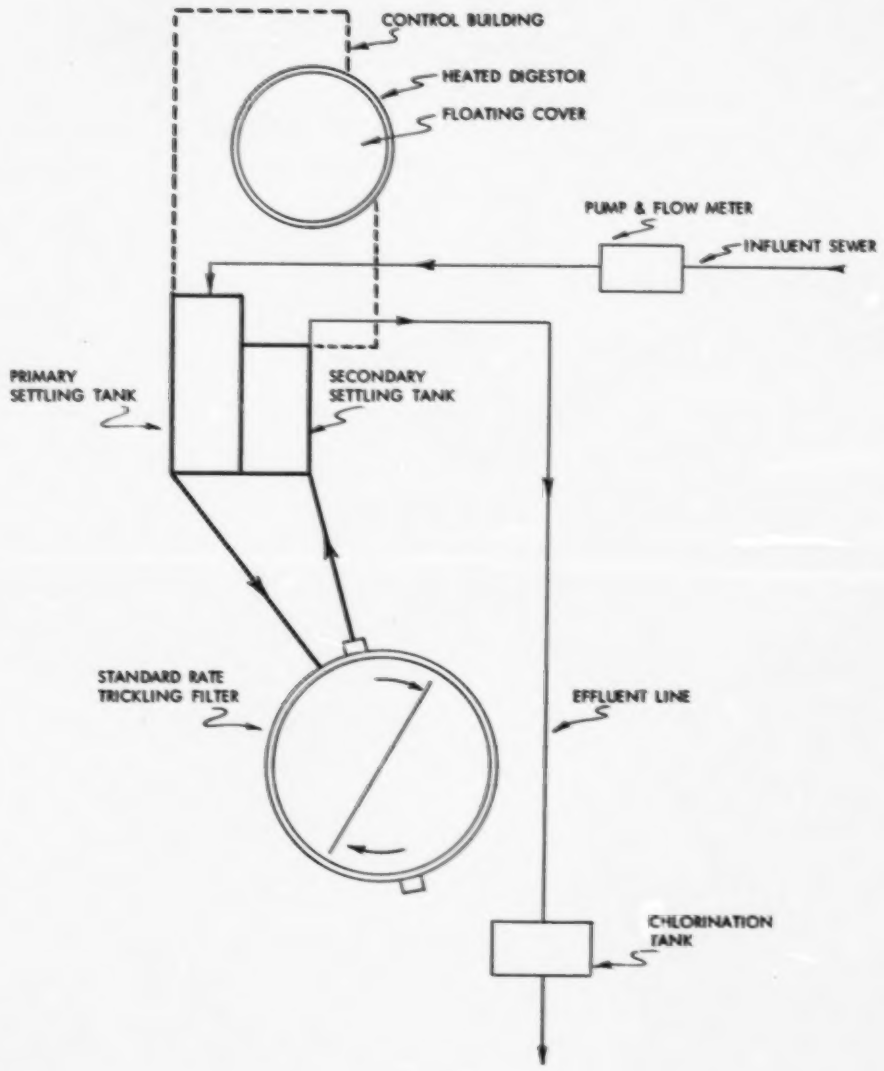


Figure 3, continued STAGE II
1080 homes

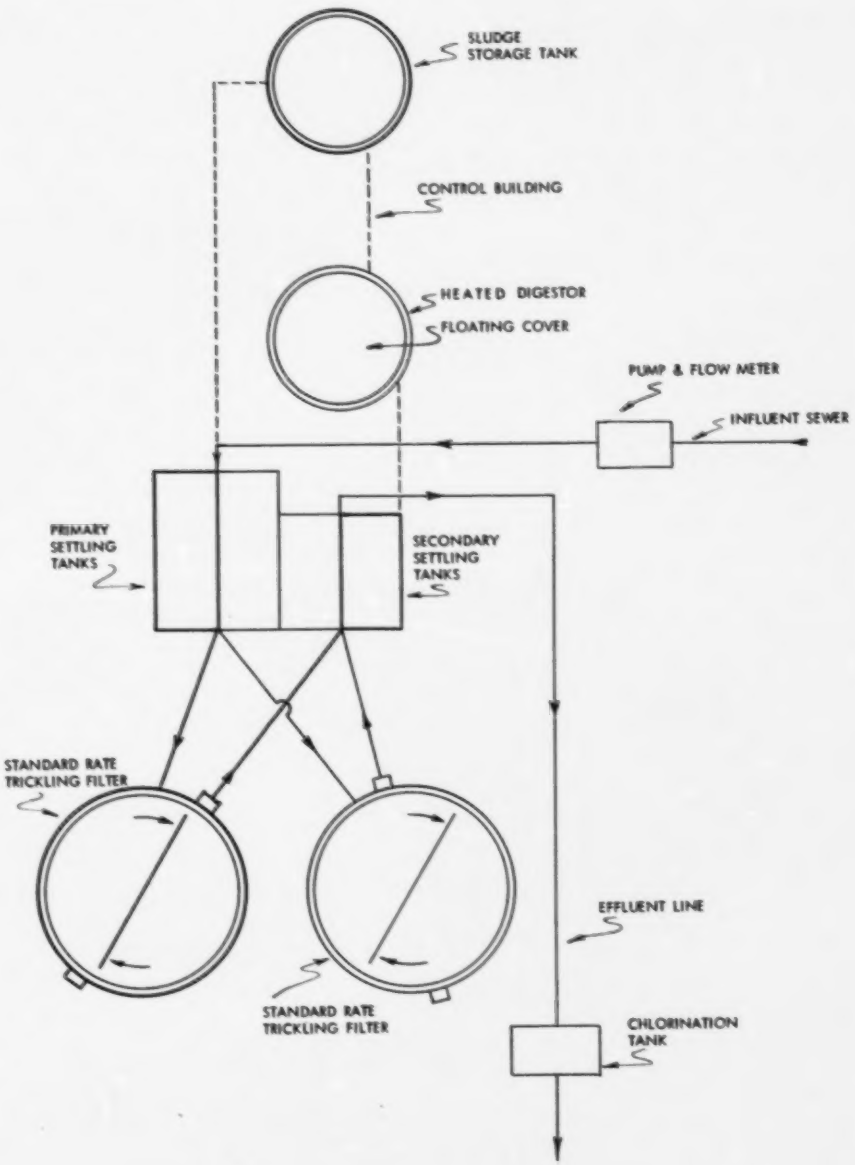


Figure 3, continued. STAGE III
2160 homes

OPERATION AND MAINTENANCE

Sewage treatment facilities cannot be expected to operate satisfactorily without supervision. The calibre and number of operating personnel required will depend upon the size and type of the facility.

Adequate operation and maintenance of a publicly owned treatment facility are provided by sewer charges or a direct levy on the home owner. Since considerable capital investment is represented by a sewage treatment plant, it is false economy to shorten its useful life with inefficient operation and inadequate maintenance. Also, poor operation may threaten the health and welfare of downstream users and may result in litigation and subsequent financial loss.

SUCCESSFUL SEWERAGE INSTALLATIONS

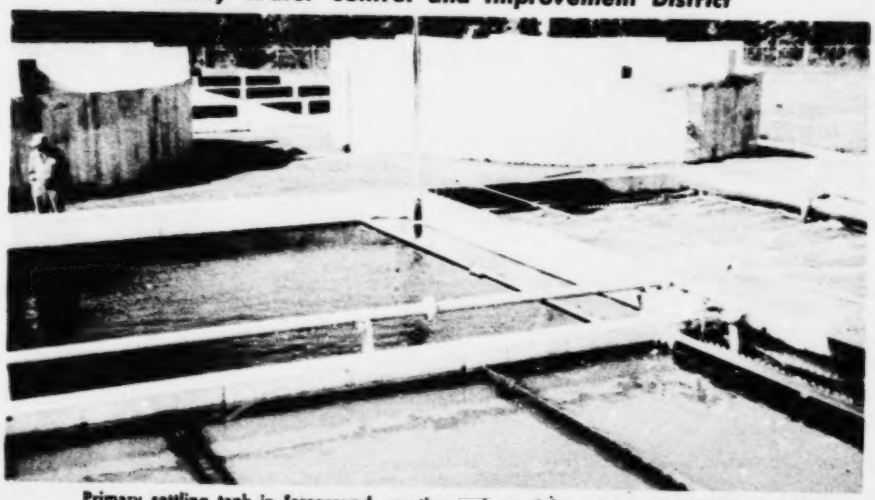
Numerous subdivisions in this country are served by separate community sewers and treatment plants. As of 1956, there were over 100 of these systems in Florida. More than 65 of these were built from 1951 to 1956. New York has several of these installations. More than a dozen such sewerage systems were reported in New Jersey and at least 20 more were under consideration in new developments in that State.

In Cook County there were two community sewerage systems, and more in other parts of Illinois. In Indiana, early in 1956, there were six subdivision developments providing sewerage facilities. Some have been built in Wisconsin and ultimately they will be included in sanitary districts.

ACTIVATED SLUDGE PLANT

Sharpstown, Harris County, Texas

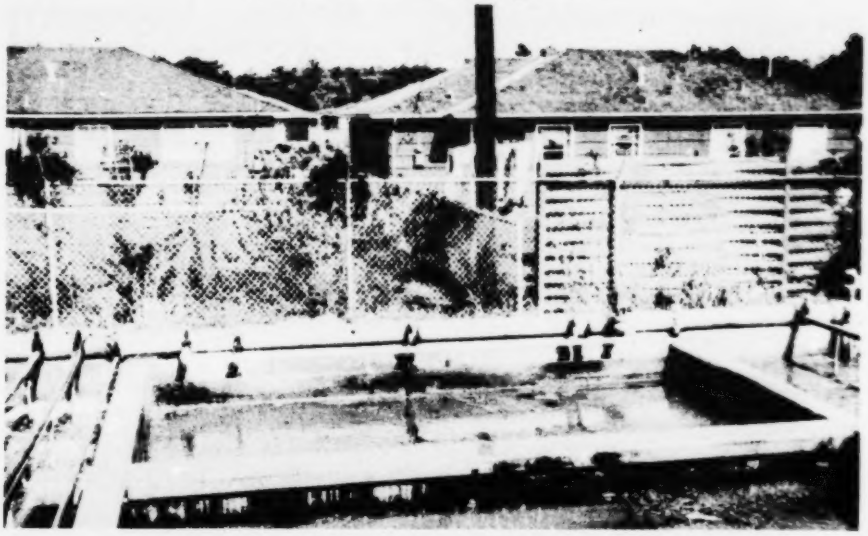
County Water Control and Improvement District



Primary settling tank in foreground, aeration tank on right and secondary settling tank at left center. Digesters and sludge drying beds in background.

AERATION UNITS

Ridgecrest, Harris County, Texas
Spring Branch Utility, Inc.



Aeration units on far left discharging to secondary settling tank in center.

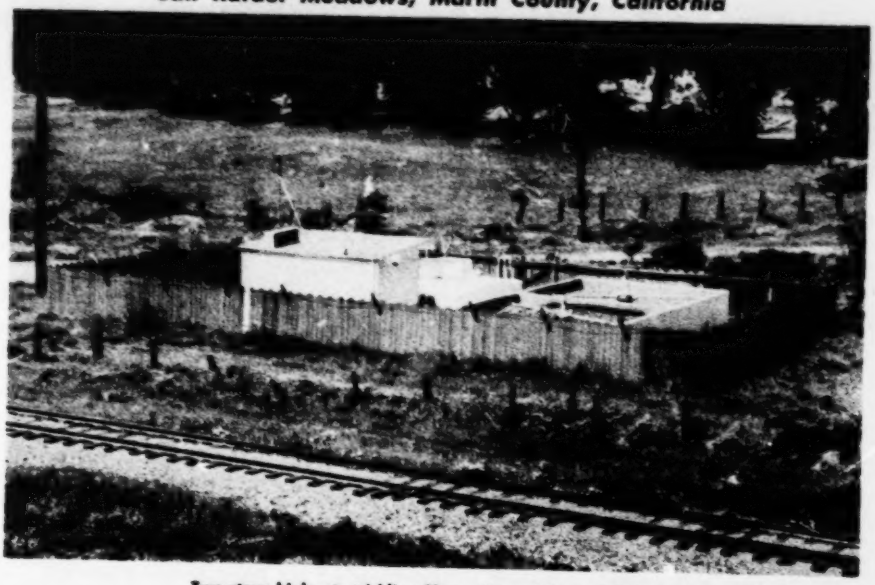
STABILIZATION PONDS

Terra Linda, Marin County, California

Stabilization ponds in series following primary sewage treatment.

HIGH-RATE TRICKLING FILTER PLANT

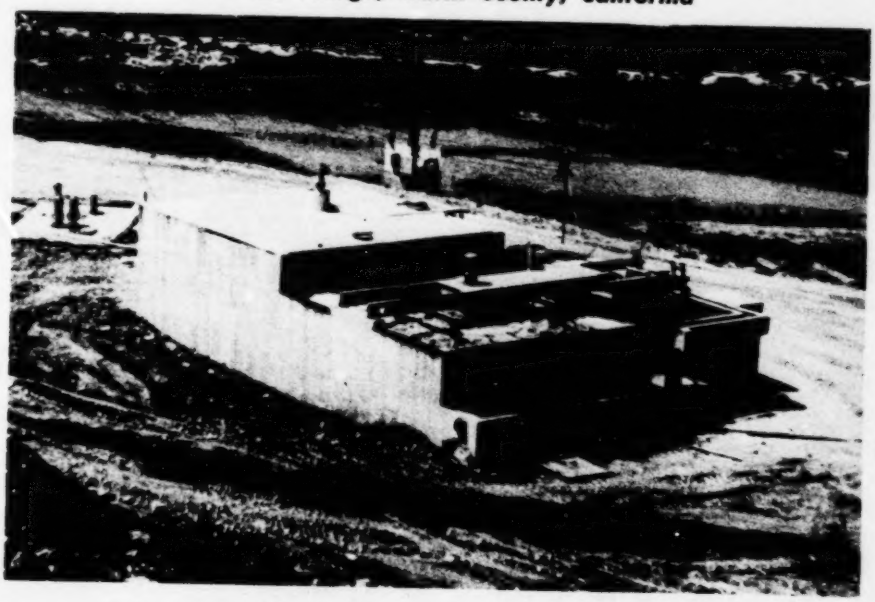
San Rafael Meadows, Marin County, California



Two-stage high-rate trickling filter. Nearest house 500 feet.

PACKAGE ACTIVATED SLUDGE PLANT

Gallinas Village, Marin County, California



TRICKLING FILTER PLANT

Johnson County, Shawnee, Kansas

Primary settling tanks in foreground, re-circulation pumps and final clarifier in background, sludge beds to right. Trickling filter out of picture at left.

CHLORINE CONTACT CHAMBER AND PARSCHAL MEASURING FLUME

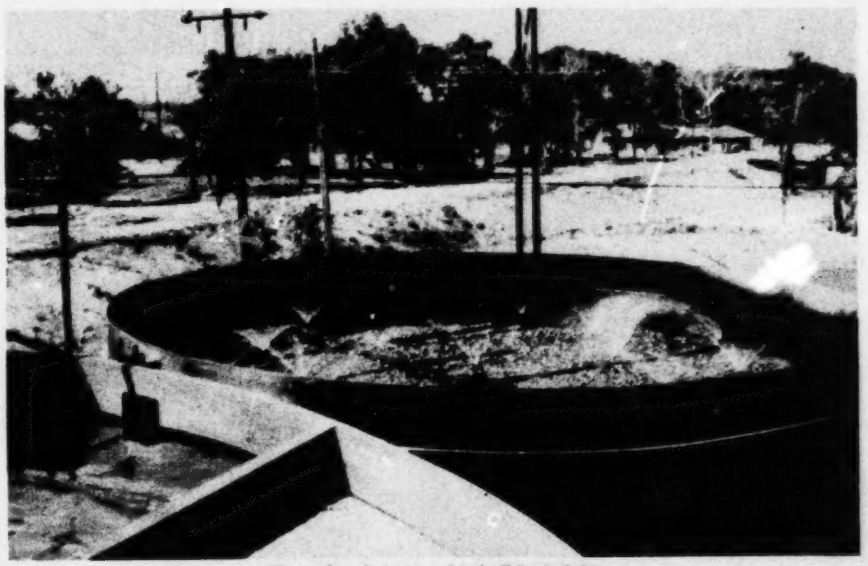
Bellaire, Texas

View shows discharge end of plant.

PRIMARY CLARIFIER
Bellaire, Texas

Laboratory pumping station in right foreground.

HIGH-RATE TRICKLING FILTER
Harris County, Texas



View taken from top of Imhoff Tank (left).

Reproduced from best available copy.

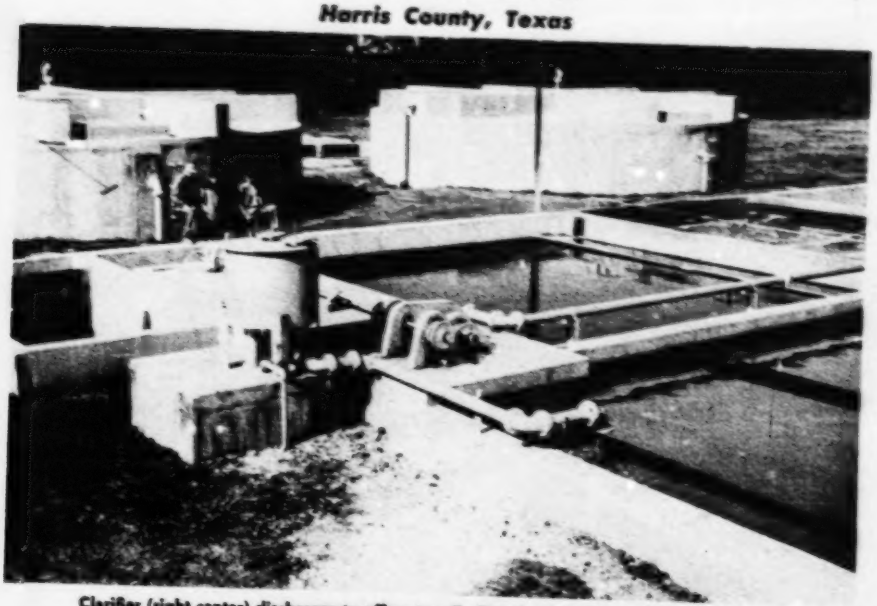
NEW TRICKLING FILTER NOT YET IN OPERATION

Harris County, Texas

Secondary clarifier barely visible behind filter unit.

SECONDARY CLARIFIER

Harris County, Texas



Clarifier (right center) discharges to effluent well, digestor and sludge bed in background.

CONTACT AERATION PLANT

Harris County, Texas

Complete plant contains wet well, one final clarifier, contact aeration unit, second final clarifier, and another contact aeration units.

In Harris County, Texas, 125 private sewage collection systems and 90 treatment plans serving subdivisions were reported. In other parts of Texas, 30 or more individual subdivision sewage plants were in operation, with many additional plants under consideration.

Five community sewerage installations were built during 1955 in Oregon. Several were constructed in California and in Colorado. More of these sewerage systems were planned in all of these States.

Many large subdivisions have recently been developed in Kansas and all have community sewers and treatment plants that were incorporated in a county or township sanitary district. Most of these are in organized main sewer districts where an over-all plan for the main sewer system has been developed. When the tax base in the main district is sufficient to finance the change, the small plants are gradually abandoned in favor of one large treatment works for the main district. There are at least 160 individual subdivision sewerage systems in Missouri, the majority of which have been constructed in the metropolitan Kansas City and St. Louis areas. Many other States are experiencing similar trends.

Cost Data on 61 Subdivisions

Detailed cost information on 61 subdivisions was obtained in the 12-State survey. This information included data on costs of septic tank installations, of suburban area sewage systems, and of conventional-type treatment plants. The treatment plants included, range in size from

facilities designed to serve only 29 homes to large subdivision systems planned to have 10,000 to 12,000 housing units ultimately. Other information was obtained on operating personnel, financing and revenue-producing service charges, and individual State administrative policy procedures. The data on these 61 subdivisions are given in Tables 1 and 2, Appendix A. Table 3 in Appendix A summarizes the construction and operation costs obtained, and shows the monthly sewer service charge for each house at the time of the survey.

Construction costs can be converted to more recent price levels by using Engineering News Record (ENR) construction cost indices. For example, a sewage treatment works that cost $244 per house in 1951 would cost approximately $244 x 759.2/542.7=$341 per house in 1958. ENR construction cost indices follow:

1913 — 100.0	1954 — 628.0
1950 — 509.6	1955 — 659.7
1951 — 542.7	1956 — 692.4
1952 — 569.4	1957 — 723.8
1953 — 600.0	1958 — 759.2

The cost of waste stabilization ponds vary substantially with the size of the installation, climatic and other conditions. The United States Public Health Service has calculated the following costs based on actual installations for a large and a small installation, as follows:

For 10,000 people

17% of the installations will cost less than $8.75 per house;
50% will cost less than $19.25 per house; and
83% will cost less than $36.40 per house.

For 300 people

17% of the installations will cost less than $39.20 per house;
50% will cost less than $67.20 per house; and
83% will cost less than $98.00 per house.

Technical Features

As might be expected, the type of sewage treatment facilities serving these 61 specific developments varied considerably (see Table 4, Appendix B). Fifty-seven of the plants studied were of the secondary type treatment, and 21 contained facilities for chlorinating the effluent. Two primary plants and two intermediate type treatment plants served the remaining four subdivisions. Both primary treatment plant effluents were provided with chlorination equipment.

Seventeen of the plants visited were of the proprietary type, i.e., package activated sludge or contact aeration. The manufacturer's capacity ratings had not been accepted at face value in most of the States visited, and before installation the units had been given a complete engineering appraisal similar to that given conventional-type treatment plants.

The last column in Table 4, Appendix B, indicates the approximate distance from the sewage treatment facility to the nearest home in the subdivision.

INCORPORATING SEWAGE COLLECTION AND TREATMENT IN THE SUBDIVISION PLAN

In the 12 States surveyed, more than 200 subdivision developers have incorporated sewerage systems in their projects from 1951 through 1956. This is partly due to the fact that most State water pollution control agencies do not favor the use of septic tanks at these locatfons.

The builders contacted in the survey utilized engineering consultation for assistance in their early planning. They also consulted with State regulatory agencies and with the Federal insuring agencies.

Steps for Builders

Information obtained from the 61 areas studied indicates that subdivision developers should take at least three steps in planning their sewerage systems.

The first step is consultation with local, municipal, or county planning and zoning boards, with Federal loan insurance agencies if they are to be involved, and in some cases with adjacent developers, with a view to the possibility of integrating the proposed system or combining it into an existing or future system.

The second step is to obtain advice from governmental regulatory agencies having control over water pollution. State enabling acts may provide for formation of a sanitary district which would assume responsibility for installation and operation of sewage facilities to treat the sewage from the proposed development. Formation of public districts takes time, so if public districts are to be used builders should allow from six months to one year for such organization. If such districts are not feasible, then the possibility of a private utility or a local home owners' association may also be explored.

Third, developers should retain a consulting sanitary engineering firm to supply the technical advice necessary for the project design. Major problems that will confront the engineer include relating the possible growth rate of the project or the rate at which the homes will be sold to the design of the sewerage facilities so that the facilities will function satisfactorily and economically at each "stage" of the subdivision development.

Approval of Plans

After the builder has taken these three steps, his engineering consultant should discuss the feasibility of the project with State, County, and other interested agencies. The State water pollution control agency will advise him of the necessary quality of the treatment plant effluent that will be required in order to maintain a satisfactory condition in the receiving watercourse. The engineer must obtain this information early in the planning stage in order to design the treatment to meet the requirements. (Names and addresses of the State and Interstate Water Pollution Control Agencies are listed in Appendix C.)

Financing

When the negotiations concerning the effluent quality and the type of sewage treatment plant required to produce it have been completed, the engineering cost estimate for the needed facilities can be determined. These questions then arise: Would one of the local governments finance the sewerage system? Would a private utility develop the sewage disposal services in view of the anticipated revenues? Would the builder be willing to finance the sewage treatment project and enter the utility business? And to what extent can the cost of this service be recaptured when the home is sold?

Many investors are interested in long-term capital gains. Since in a few cases this was possible, the opportunity for long-term capital gains should be explored.

The Federal Housing Administration has its own form of trust deed where the system is to be owned by a private corporation for profit. It also has special provisions for the charter of a property owners' association.

Revenue from the Sewerage System

The owner of a sewerage system, whether a private corporation or a local governmental unit, must provide administration and satisfactory operation and maintenance. Every sewerage system, either through direct or indirect revenues, must be able to meet its cost of operation and maintenance if it is to continue to provide the required service. In order to attract the capital for construction of private sewerage systems the revenues obtained must, within a reasonable length of time, be sufficient to pay an adequate return.

Annual costs, including operation, maintenance, interest, and depreciation on a sewage treatment plant, are generally derived from service charges. A service charge is sometimes based on the metered water consumption. If the water is not metered, then a flat rate is charged for each sewer connection, or for the number and kind of water outlets such as sinks, electric dishwashers, washing machines, flush toilets, and bathtubs.

No single regular source of funds is known for the financing of sewage treatment units. The developer must in each case use his own ingenuity in obtaining funds.

GLOSSARY

Activated Sludge. Sludge floc produced in raw or settled sewage by the growth of zoogleal bacteria and other organisms in the presence of dissolved oxygen, and accumulated in sufficient concentration by returning floc previously formed.

Activated Sludge Process. A biological sewage treatment process in which a mixture of sewage and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated sewage by sedimentation, and wasted (to a digestion tank or other sludge disposal system) or returned to the process as needed.

Aeration. The bringing about of intimate contact between air and a liquid by one of the following methods: spraying the liquid in the air; bubbling air through the liquid; or by agitation of the liquid to promote surface absorption of air.

Aerobic Bacteria. Bacteria which require free (elementary) oxygen for their growth.

Algae. Primitive organisms of the plant family, one- or many-celled, usually aquatic and capable of elaborating their foodstuffs by photosynthesis.

Anaerobic Bacteria. Bacteria which grow in the absence of free oxygen and derive oxygen from breaking down complex substances.

Bacteria. Primitive plants, generally free of pigment, which reproduce by dividing in one, two, or three planes. They occur as single cells, groups, chains, or filaments, and do not require light for their life processes.

Bar Rack. A screen composed of parallel bars, either vertical or inclined, placed in a waterway to catch floating debris, and from which the screenings may be raked.

Chlorination. The addition of chlorine or compounds containing available chlorine to sewage in order to assist the processes of purification and to control odor.

Chlorine Contact Chamber. A detention basin wherein chlorine is diffused through liquid.

Clarifier. (See Primary Settling Tank, Secondary Settling Tank.)

Coagulation. The massing together of colloidal or finely divided suspended matter by the addition to the liquid of an appropriate chemical coagulant, by biological processes, or by other means.

"Complete" Sewage Treatment. The removal of a high percentage of suspended, colloidal, and dissolved organic matter, usually by a combination of sedimentation (primary treatment) with some form of oxidation process (secondary treatment).

Contact Aeration. The process in which contact beds are continuously submerged in the sewage they treat, with air being blown through the bed to maintain circulation of the sewage and to supply oxygen requirements for the biological film.

Digester. A tank in which solids resulting from the sedimentation of sewage are stored for the purpose of permitting anaerobic decomposi-

tion to the point of rendering the product nonputrescible and inoffensive. Sometimes called *sludge digester.*

Digestion. The anaerobic decomposition of organic matter, resulting in partial gasification, liquefaction, and mineralization.

Effluent. Sewage, water, or other liquid, partially or completely treated, as the case may be, flowing out of a treatment plant or part thereof.

Filter. A device or structure for removing solid or colloidal material, usually of a type that cannot be removed by sedimentation from water, sewage, or other liquid.

Floc. Small gelatinous masses, formed in a liquid by the addition of coagulants thereto or through biochemical processes or by agglomeration.

Flocculation. The formation of flocs.

Flocculator. An apparatus for the formation of floc in water or sewage.

Grit. The heavy mineral matter in water and sewage, such as sand, gravel, or cinders.

Grit Chamber. A small detention chamber or an enlargement of a sewer designed to reduce the velocity of flow of the liquid to permit the separation of grit from organic solids by differential sedimentation.

Imhoff Tank. A deep two-storied sewage tank, originally patented by Karl Imhoff, consisting of an upper or continuous-flow sedimentation chamber and a lower or sludge-digestion chamber. The floor of the upper chamber slopes steeply to trapped slots, through which solids may slide into the lower chamber. The lower chamber receives no fresh sewage directly, but is provided with gas vents and with means for draining digested sludge from near the bottom.

Influent. Raw sewage flowing into a treatment plant.

Intercepting Sewer. A sewer which receives dry-weather flow from a number of transverse sewers and conducts such waters to a point for treatment or disposal.

Intermediate Sewage Treatment. The removal of a high percentage of suspended solids and a substantial percentage of colloidal matter, but little dissolved matter.

Intermittent Sand Filter. A natural or artificial bed of sand or other fine-grained material to which sewage is applied in intermittent doses and through which it percolates to underdrains.

Pre-aeration. A preparatory treatment of sewage comprising aeration to remove gases, add oxygen, or promote flotation of grease, and aid coagulation.

Primary Settling Tank. The first settling tank through which sewage is passed in a treatment works. Also called *primary clarifier.*

Primary Sewage Treatment. The first major (sometimes the only) treatment in a sewage treatment works, usually sedimentation. The removal of high percentage of suspended matter, but little or no colloidal and dissolved matter.

Sanitary Sewage. Domestic sewage with storm and surface waters excluded.

Secondary Settling Tank. A tank through which the effluent from a trickling filter, or aeration or contact aeration tank flows for the purpose of removing the settleable solids. Also called *final settling tank, final settling basin,* and *secondary clarifier.*

Secondary Sewage Treatment. The treatment of sewage by biological methods after primary treatment by sedimentation.

Sedimentation. The process of settling and deposition of suspended matter carried by water, sewage, or other liquids, by gravity. This is usually accomplished by reducing the velocity of the liquid below the point where it can transport the suspended material.

Sedimentation Tank. A tank or basin, in which water, sewage or other liquid containing settleable solids, is retained for a sufficient time, and in which the velocity of flow is sufficiently low to remove by gravity a part of the suspended matter. Also called *settling tank.*

Septic Tank. A single-story settling tank in which the settled sludge is in immediate contact with the sewage flowing through the tank, while the organic solids are decomposed by anaerobic bacterial action. (As used in this booklet, the term "septic tank" infers subsurface disposal of the effluent which is usually accomplished by cesspools or subsurface tile drains.)

Sewage. Largely the water supply of a community after it has been fouled by various uses. As used in this booklet, it is a combination of the liquid or water-carried wastes from residences.

Sewage Treatment Plant. An arrangement of devices and structures for treating sewage, industrial wastes, and sludge. Sometimes used as synonymous with *sewage treatment works.*

Sewer. A pipe or conduit, generally closed and normally not flowing full, for carrying sewage and other waste liquids.

Sewerage System. A system of sewers and appurtenances for the collection, transportation, pumping, and treatment of sewage and industrial wastes.

Sludge. The accumulated settled solids deposited from sewage or industrial wastes, raw or treated, in tanks or basins, and containing more or less water to form a semi-liquid mass.

Stabilization Pond. A pond, natural or artificial, into which untreated or partly treated sewage is discharged and in which natural purification processes take place under the influence of sunlight and air. Also called *oxidation pond, stabilization basin,* and *lagoon.*

Trickling Filter. A filter consisting of an artificial bed of coarse material, such as broken stone, clinkers, slate, slats, or brush, over which sewage is distributed and applied in a spray and through which it trickles to the underdrains, giving opportunity for the formation of zoogleal slimes on the stones which clarify and oxidize the sewage. A high-rate trickling filter is one operated at a high average daily dosing rate which is sometimes obtained by re-circulating part of the filter effluent.

APPENDIX A

TABLE 1

SEWAGE COLLECTION SYSTEM DATA AND COSTS FOR SELECTED SUBDIVISIONS

(Not Including Treatment Plant or House Laterals)

	Houses to be Served			Sewers[1] Construction Cost					Lift Stations[2]	
Installation	At Time Data Was Obtained (Houses)	Ultimate Development (Houses)	Lot Area (Acres)	Total Length of Sewer System (1000′)	Total ($)[3]	Per House Built At Time Data Was Obtained ($)[3]	Per Foot ($)	Year Built (1900s)	No.	Construction Cost Per House ($)[3]
Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
FLORIDA										
1′	12	4,000	—[5]	—[5]	—[5]	305	—[5]	51-54	—[5]	64
2′	125	—[5]	—[5]	—[5]	—[5]	340	—[5]	51-54	—[5]	134
3′	600	12,000	—[5]	—[5]	—[5]	221	—[5]	51-54	—[5]	33
4′	420	3,000	—[5]	—[5]	—[5]	469	—[5]	51-54	—[5]	23
5′	200	4,000	—[5]	—[5]	—[5]	290	—[5]	51-54	—[5]	37
6′	100	600	—[5]	—[5]	—[5]	220	—[5]	51-54	—[5]	38
7′	294	—[5]	—[5]	—[5]	—[5]	240	—[5]	51-54	—[5]	59
8	60	90	0.30	4.2	13,900	232	3.31	53-55	1	—[6]
9	153	153	0.16	6.1	16,000	105	2.62	52-55	0	—
10	720	3,600	0.19	51.8	200,000	278	3.86	51-55	0	—
11	451	2,000	0.18	35.1	122,328[6]	170	3.49	53-55	3	—[7]
NEW YORK										
12	70	206	—[5]	6.6	45,000	218	6.82	55	0	—
13	159	347	0.21	17.0	—[5]	—[5]	—[5]	50-55	0	—
NEW JERSEY										
14	0	125	0.18	5.0	51,000	408	10.20	55&56	0	—
15′	0	330	0.18	14.0	75,500	228	5.40	56	1	61
16′	180	1,200	0.18	48.0	250,000	208	5.21	55&56	0	—
17′	200	275	0.18	11.0	56,000	197	5.10	54-56	0	—
18′	0	100	0.18	4.5	20,000	200	4.45	56	0	—
19′	250	500	0.18	—[5]	—[5]	244[6]	—[5]	54-56	0	—
20′	200	300	0.17	14.0	70,000	233	5.00	53-55	0	—
21′	316	316	0.20	—[5]	—[5]	244	—[5]	53	1	30

TABLE 1 — (Continued)

Installation	Houses to be Served			Sewers' Construction Cost					Lift Stations[7]	
	At Time Data Was Obtained (Houses)	Ultimate Development (Houses)	Lot Area (Acres)	Total Length of Sewer System (1000')	Total ($)[8]	Per House Built At Time Data Was Obtained ($)[8]	Per Foot ($)	Year Built (1900s)	No.	Construction Cost Per House ($)[8]
Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
NEW JERSEY (Cont.)										
22[4]	100	300	0.17	—[9]	—[9]	244[9]	—[9]	54&55	0	—
23	1	76	0.18	3.25	17,000	223	5.23	55&56	1	158
24[4]	300	600	0.17	25.0	115,000	192	4.60	54-56	1	25
25[4]	0	600	0.18	24.0	125,000	208	5.23	56	0	—
26[4]	300	750	—[9]	—[9]	—[9]	244[9]	—[9]	53	0	—
27	53	330	0.18	14.2	70,000	212	4.92	55&56	1	76
28[4]	42	240	0.20	9.5	50,000	209	5.27	56	1	55
29	71	71	0.18	3.5	18,000	254	5.15	54&55	0	—
ILLINOIS										
30[4]	60	1,600	0.50[10]	18.6	25,200	420[11]	1.36	55	0	—
31[4]	90	164	0.18	7.1	14,420	161	2.04	55	0	—
32	400[12]	4,000	0.15	30.12[13]	105,160[13]	263	3.50	56	0	—
INDIANA										
33	65[14]	143	0.32	13.8	53,510	388	3.89	55	0	—
34	0[15]	75[16]	0.34	5.7	26,500	354	4.65	56	0	—
35	240	1,500	0.19	12.1	42,000	175	3.47	55	0	—
36	75	1,600	0.34	11.0[17]	82,000[17]	—[18]	7.45	55	0	—
WISCONSIN										
37	225	500	—[9]	16.1	—[9]	—[9]	—[9]	55&56	0	—
KANSAS										
38	200	330	0.20	7.73	38,200	191	4.95	52	1	23
KANSAS (Cont.)										
39	230	375	0.22	9.5	46,100	201	4.85	53	0	—
40	114	140	0.18	5.3	25,600	225	4.83	53	0	—
COLORADO										
41	2,100	2,800	0.18	111.79[19]	367,500	175	3.11	54	0	—
42	715	1,750	0.16	46.98[20]	84,300	118	1.80	54	0	—

TABLE 1 – (Continued)

Installation	Houses to be Served: At Time Data Was Obtained (Houses)	Houses to be Served: Ultimate Development (Houses)	Houses to be Served: Lot Area (Acres)	Sewers[1] Construction Cost: Total Length of Sewer System (1000')	Sewers[1] Construction Cost: Total ($)[2]	Sewers[1] Construction Cost: Per House Built At Time Data Was Obtained ($)[2]	Sewers[1] Construction Cost: Per Foot ($)	Sewers[1] Construction Cost: Year Built (1900s)	Lift Stations[2]: No.	Lift Stations[2]: Construction Cost Per House ($)[2]
Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
OREGON										
43	50	160	0.26	—[5]	80,000	500	—[5]	54&55	0	—
44	50	540	0.25	9.5	38,000[21]	380[22]	4.00	55	0	—
MISSOURI										
45	25	50	0.18	4.5	10,000[23]	400	2.22	55	0	—
46	1,840	1,840	0.18	—[5]	552,000	300	—[5]	52	3	20
47	0	275	0.20	3.96	10,700[24]	389	2.70	56	0	—
48	12	50	0.22	2.72	9,910	198	3.65	56	0	—
CALIFORNIA										
49	0	1,310	—[5]	—[5]	—[5]	—[5]	—[5]	56	0	—
50	420	625	0.14	18.6	64,900	154	3.00	51-55	2	40
TEXAS										
51[4]	30	70	0.40	4.49	9,468[25]	315[26]	2.11	55&56	0	—
52[4]	200	2,500	0.19	26.4[26]	70,000[27]	189[27]	4.35	54-56	0	—
53[26]	400	1,880	0.17	34.3	65,000	162	1.89	54-56	0	—
54[26]	689	25,000	0.16[26]	77.2[26]	334,000[26]	300	4.33	55&56	2	28
55	15	29	0.28	4.16	5,800	200	1.39	54-56	0	—
56[4]	800	1,000	0.18	13.21	73,738	92	5.58	50-55	0	—
57[26]	300	5,000	0.22	—[5]	421,705[21]	184[21]	—[5]	55&56	0	—
58[4]	80	1,000	0.18	—[5]	6,000	75	—[5]	54-56	0	—
59[4]	450	770	0.15	23.91	43,997	98	1.84	50-55	0	—
60[4]	140	355	0.19	9.09	16,010[22]	113[22]	1.76	53-56	0	—
61[4]	609	644	0.18	—[5]	70,000[28]	125[28]	—[5]	50-54	0	—

Footnotes:

1. Does not include house laterals.
2. Lift stations in the collection system. Does not include pumping facilities located at treatment plant.
3. To nearest dollar. Does not include land cost, legal and engineering fees, or cost of house laterals.
4. Served by private utility.
5. Complete data not furnished.
6. Cost of collection system to serve 722 houses. Includes cost of three sewage lift stations.
7. Included in collection system cost.

TABLE 1 — (Continued)

8. See plant cost, Table 2.
9. Engineering estimate. Complete costs had not been determined.
10. First 250 homes are on 0.50 acre lots. The remaining 1,350 homes to be on 0.25 acre lots.
11. Developer estimates this $420 sewer cost for 0.50 acre lots will reduce to $315 for 0.25 acre lots.
12. Seventy-five were under construction, 325 occupied.
13. Based on sewer construction for the first portion of system.
14. Thirty-five of these were unoccupied.
15. Thirty were under construction.
16. First section of three sections being developed.
17. Trunk and intercepting sewers only were being constructed by land developer. Street sewers to be put in by individual home builders in proposed subdivisions.
18. Not applicable.
19. Includes 11,800 feet of outfall sewer to treatment plant.
20. Includes 6,830 feet of outfall sewer to treatment plant.
21. Does not include offsite collecting interceptor to serve the ultimate development. Cost for this sewer will be approximately $28 per lot and $5.80 per foot.
22. Based on sewer construction for 100 houses.
23. Includes 1,900 feet of offsite sewer to treatment plant.
24. Contractor's low bid.
25. Includes cost of house laterals.
26. Includes 3,000 feet of 21 inch offsite sewer outfall to treatment plant.
27. Cost for 370 houses. Developer estimates sewers for the remaining 2,130 houses to be constructed will cost an additional $25,000, reducing the per lot cost to $38.
28. County Water Control and Improvement District formed on petition of developers.
29. Minimum size.
30. Includes trunk sewers and outfall line to plant that will serve other developers.
31. Cost for 2,282 lots.
32. Cost for 142 lots.
33. Cost for 644 lots.

TABLE 2

SEWAGE TREATMENT PLANT DATA AND COSTS FOR SELECTED SUBDIVISIONS

	Houses to be Served			Treatment Plant[1]				
				Construction Cost Based on Plant Design Capacity				
Installation	At Time Data Was Obtained (Houses)	Plant Design Capacity (Houses)	Ultimate Development (Houses)	Total ($)[2]	Per House ($)[3]	Year Built (1900s)	Cost of Operation & Maint. Per Year ($)	Degree of Treatment
Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FLORIDA								
1[4]	12	—[4]	4,000	—[4]	492	51-54	—[4]	Intermediate
2[5]	125	—[4]	—[4]	—[4]	244	51-54	—[4]	Secondary
3[5]	600	—[4]	12,000	—[4]	145	51-54	—[4]	Secondary
4[5]	420	—[4]	3,000	—[4]	254	51-54	—[4]	Secondary
5[5]	200	—[4]	4,000	—[4]	86	51-54	—[4]	Secondary
6[5]	100	—[4]	600	—[4]	168	51-54	—[4]	Secondary
7[5]	294	—[4]	—[4]	—[4]	73	51-54	—[4]	Secondary
8	20	90	90	20,000	222	53-55	220[6]	Primary
9	153	153	153	44,000	288	52-55	—[6]	Secondary
10	720	1,710	3,600	140,000	82	51-55	4,450	Secondary
11	451	600	2,000	84,420	141	53-55	3,014[7]	Secondary
NEW YORK								
12	70	206	206	72,000	349	55	—[8]	Secondary
13	159	347	347	110,000[9]	—[9]	50-55	—[10]	Primary
NEW JERSEY								
14	80	200[11]	200[11]	50,000[13]	250[12]	55&56	5,340[13]	Secondary
15[5]	—[14]	—[14]	—[14]	—[14]	279[14]	56	—[14]	---
16[5]	180	475	1,200	150,000	316	55&56	5,650	Secondary
17[5]	200	430[15]	705[15]	120,000	279	54-56	5,040	Secondary
18[5]	—[14]	—[14]	—[14]	—[14]	279[14]	56	—[14]	---
19[5]	250	500	500	55,500	111	54-56	8,700[16]	Secondary
20[5]	200	300	300	90,000	300	53-55	5,940	Secondary
21[5]	316	300	316	55,430	175	53	8,700[16]	Secondary
22[5]	100	300	300	56,156	187	54&55	8,700[16]	Secondary
23	1,500[17]	2,500	2,500	160,000[18]	64	55&56	13,200[18]	Secondary
24	300	475	1,440[19]	120,000	252	54-56	8,950	Secondary
25[5]	—[19]	—[19]	—[19]	—[19]	252[20]	56	—[19]	---
26[5]	300	250	750	42,000	140	53	8,700	Secondary

TABLE 2 — (Continued)

Installation	Houses to be Served: At Time Data Was Obtained (Houses)	Houses to be Served: Plant Design Capacity (Houses)	Houses to be Served: Ultimate Development (Houses)	Treatment Plant[1]: Construction Cost Based on Plant Design Capacity: Total ($)[2]	Treatment Plant[1]: Construction Cost Based on Plant Design Capacity: Per House ($)[2]	Treatment Plant[1]: Year Built (1900s)	Treatment Plant[1]: Cost of Operation & Maint. Per Year ($)	Treatment Plant[1]: Degree of Treatment
Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NEW JERSEY (Cont.)								
27	1,200[21]	2,400	2,400	250,000[12]	104	55&56	15,300[12]	Secondary
28[3]	—[22]	—[22]	—[22]	—[22]	252	56	—[22]	--------
29	—[23]	—[23]	—[23]	—[23]	64	54&55	—[23]	Intermediate
ILLINOIS								
30[3]	60	1,600	1,600	150,000	94	55	—[6]	Secondary
31[3,24]	120	750	2,000	106,000	141	55	—[6]	Secondary
32	1,000[25]	3,000	5,000	324,800	108[12]	56	—[12,26]	Secondary
INDIANA								
33	30	143	265[27]	18,000	126	55	—[6]	Secondary
34	0[28]	110	190[28]	31,990	291	56	—[6]	Secondary
35	240	222[29]	1,500	70,000	291[29]	55	2,640	Secondary
36	—[32]	—[32]	—[32]	—[32]	—[32]	55	—[32]	--------
WISCONSIN								
37	225[33]	500[34]	500	95,000[35]	190[12]	55&56	—[6,12]	Secondary
KANSAS								
38	200	330	330	61,000[36]	139[36]	52	1,200[37]	Secondary
39	230[38]	150	425[38]	24,800	165	53	1,815[39]	Secondary
40	114	140	140	32,500	232	53	2,780	Secondary
COLORADO								
41	2,100	2,800	2,800	228,000	81	54	8,100	Secondary
42	715	1,750	1,750	164,000	94	54	—[6]	Secondary
OREGON								
43	50	250[40]	250[40]	49,500	198	54&55	4,800	Secondary
44	50	300	540	77,000	226	55	—[6]	Secondary
MISSOURI								
45	25	200	840	4,500[41]	222[42]	55	—[43]	Secondary
46	1,840	2,700[44]	1,840	322,500	119	52	20,200[12]	Secondary
47	0	275	275	6,000[41]	222[42]	56	—[43]	Secondary
48	12	153[44]	50	2,500[41]	216[42]	56	—[43]	Secondary

TABLE 2 — (Continued)

Installation	Houses to be Served: At Time Data Was Obtained (Houses)	Houses to be Served: Plant Design Capacity (Houses)	Houses to be Served: Ultimate Development (Houses)	Treatment Plant[1]: Construction Cost Based on Plant Design Capacity: Total ($)[2]	Treatment Plant[1]: Construction Cost Based on Plant Design Capacity: Per House ($)[2]	Treatment Plant[1]: Year Built (1900s)	Treatment Plant[1]: Cost of Operation & Maint. Per Year ($)	Degree of Treatment
Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CALIFORNIA								
49	0	1,310	1,310	140,640[45]	120	56	—[46]	Secondary
50	420	625	625	130,000	208	51-55	1,330[47]	Secondary
TEXAS								
51[3]	30	70	70	8,600	123	55&56	1,292[48]	Secondary
52[49]	250	650	5,000	24,000	37[50]	54-56	2,395	Secondary
53[51]	400	675	1,880	67,907	101	54-56	—[6 13]	Secondary
54[51]	689	2,700	25,000	138,000	51	55&56	—[6 13]	Secondary
55	15	29	29	12,615	435	54-56	1,195[52]	Secondary
56[3]	800	1,000	1,000	86,539	87	50-55	—[4]	Secondary
57[21]	300	5,000	5,000	238,988	48	55&56	—[6 13]	Secondary
58[3]	60	1,000	1,000	31,000	31	54-56	—[4]	Secondary
59[3]	450	770	770	32,500	42	50-55	—[4]	Secondary
60[3]	140	355	355	38,022	107	53-56	—[4]	Secondary
61[3]	1,700	2,300	—[4]	150,000	65	50-54	17,460	Secondary

Footnotes:

1. Includes pumping stations and recirculation facilities located at plant.
2. To nearest dollar. Does not include land or legal and engineering fees.
3. Served by private utility.
4. Complete data not furnished.
5. Does not include power cost.
6. Plant had not been in operation for sufficient time to indicate reliable operation and maintenance cost.
7. Includes cost of power, operation, and maintenance for the three sewage lift stations in the sewer collection system.
8. Includes cost of complete sewer system and treatment plant.
9. See Summary of Costs for plant and sewers, Table 3.
10. Local government agency has purchased facilities. This agency operates several systems and does not maintain separate cost records.
11. Plant designed to also treat sewage from an adjoining subdivision.
12. Financed through bond issue by local government agency. $75 per connection contributed by subdividers.
13. Borne by local government agency.
14. Served by treatment plant for which data is given for Installation 17.
15. Plant designed to serve also Installations 15 and 18.
16. Engineering estimate.
17. Local government plant, also serving Installation 29.
18. Plant to also ultimately serve Installations 25 and 28.
19. Served by treatment plant for which data is given for Installation 24.
20. $400 per connection contributed by subdivider.
21. Local government plant.
22. Sewage to Installation 24.

TABLE 2 — (Continued)

23. Sewage to local government plant also serving Installation 23.
24. Will ultimately serve seven subdivisions with a potential of 2,000 homes.
25. Village plant was constructed in Dec. 1955 and Jan. 1956, through bond issue.
26. Plant had not been in operation for sufficient time to indicate reliable cost. Engineering estimate of cost is $13,000 per year.
27. Prior to full development the sewage collection system will be integrated into a metropolitan sanitary district sewer system.
28. Thirty were under construction.
29. First section of three sections was being developed. Ultimate three-section development will be 190 lots.
30. Plant was being expanded.
31. Based on houses served.
32. Sewage to municipal constructed and operated treatment plant.
33. Temporary lagooning treatment facilities approved to receive sewage from 225 homes.
34. Permanent treatment plant was under construction.
35. Cost of permanent facilities then under construction.
36. Actual developers cost only $46,000, as $15,000 was contributed by a connecting school (900 pupils).
37. Includes power only for plant and lift station as developer does not keep cost on labor required.
38. Includes a country club connection, considered equivalent to 50 homes.
39. 1955 cost. First four months of 1956 was $832.72.
40. Plant designed to treat wastes from 90 additional houses other than those in the subdivision reported.
41. Construction cost of sewage stabilization basin for temporary treatment.
42. Includes cost of construction of sewage stabilization basin and $200 placed in escrow by the developer toward extension of sewers and permanent treatment facility.
43. Negligible cost of operation for sewage stabilization basin.
44. Designed for additional load other than subdivision currently served.
45. Low bid. Construction was to start in June 1956.
46. Not then in operation.
47. Includes only cost of power and water for operation of the two lift stations and the treatment plant.
48. Includes $272 for school, county, and State taxes.
49. Two subdivision utility companies jointly own the sewage treatment plant.
50. Cost for land, engineering, and a power line to the plant was an additional $22 per house.
51. County Water Control and Improvement District formed on petition of developers.
52. Includes $320 per year for school, county, and State taxes.

TABLE 3

SUMMARY OF SEWAGE COLLECTION AND TREATMENT PLANT COSTS

Installation	Construction Cost Per House Based on Design Capacity	Operation and Maintenance Cost Per House Per Month	Sewer Service Charge Per House Per Month
	($)[1]	($)[2]	($)
Column	(1)	(2)	(3)
FLORIDA			
1[3]	861	—[4]	2.50[5]
2[3]	718	—[4]	2.50[5]
3[3]	399	—[4]	3.00[5]
4[3]	746	—[4]	3.00
5[3]	413	—[4]	3.00[5]
6[3]	426	—[4]	2.50[5]
7[3]	372	—[4]	—[4]
8	454	0.92[7]	2.50
9	393	—[8]	2.50
10	360	0.52	2.50
11	311	0.56	2.50
NEW YORK			
12	567	—[8]	2.50
13	317	—[8]	2.50
NEW JERSEY			
14	658	5.57[9]	1.60
15[3]	568	—[10]	4.00
16[3]	524	2.62	4.00
17[3]	476	2.10	4.00
18[3]	479	—[10]	4.00
19[3]	355	2.89	3.33
20[3]	533	2.47	4.00
21[3]	449	2.29	2.50
22[3]	431	7.25	2.50
23	445	0.73[9]	1.60
24[3]	469	2.48	4.00
25[3]	460	—[11]	4.00
26[3]	384	2.41	3.50
27	392	1.06[9]	1.60
28[3]	516[12]	—[11]	4.00
29	318	0.73[9]	1.60

TABLE 3 – (Continued)

Installation	Construction Cost Per House Based on Design Capacity	Operation and Maintenance Cost Per House Per Month	Sewer Service Charge Per House Per Month
	($)[1]	($)[2]	($)
Column	(1)	(2)	(3)
ILLINOIS			
30[9]	514	—[6]	3.50
31[9]	302	—[6]	3.50
32	371	—[6,9]	2.00
INDIANA			
33	514	—[6]	—[13]
34	480[14]	—[6]	—[13]
35	466	0.92	3.75
36	51[15]	—[6]	3.38[16]
WISCONSIN			
37	—[4]	—[6]	2.00
KANSAS			
38	353	0.50[17]	2.00[18]
39	366	0.76	1.00
40	457	2.03	1.83
COLORADO			
41	256	0.24	2.50
42	212	—[6]	1.50
OREGON			
43	698	8.00	2.00
44	606	—[6]	1.90
MISSOURI			
45	622	None	—[19]
46	439	0.63[9]	1.00
47	611	None	1.00
48	414	None	1.00
CALIFORNIA			
49	120[20]	—[21]	2.75
50	402	0.26	—[21]
TEXAS			
51[9]	438[22]	3.59	1.50
52[9]	226	0.80	2.00

TABLE 3 – (Continued)

Installation	Construction Cost Per House Based on Design Capacity	Operation and Maintenance Cost Per House Per Month	Sewer Service Charge Per House Per Month
	($)[1]	($)[2]	($)
Column	(1)	(2)	(3)
TEXAS (Cont.)			
53[23]	263	—[9]	2.00
54[23]	374	—[9]	1.50
55	635	6.63	2.50
56[3]	179	—[4]	1.50
57[23]	232	—[9]	—[21]
58[3]	106	—[4]	1.50
59[3]	140	—[4]	2.00
60[3]	220	—[4]	1.50
61[3]	190	0.86	1.50

Footnotes:

1. To nearest dollar. Includes sewers, lift stations and treatment plant. Does not include cost of land, house laterals, or legal and engineering fees.
2. Includes operating costs of lift and plant pumping stations. Based on connections at time data was obtained.
3. Served by private utility.
4. Complete data not furnished.
5. For one-bathroom house—$3.00 for two bathrooms.
6. For one-bathroom house—$3.50 for two bathrooms.
7. Does not include power cost.
8. Plant had not been in operation for sufficient time to indicate reliable operation and maintenance cost.
9. Borne by local government operating agency.
10. Borne by Installation 17.
11. Borne by Installation 24.
12. Subdivider's cost was $609: $209 for sewers, and $400 contribution per connection.
13. No sewer service charge until taken into metropolitan sanitary district interceptor. Then the charge will be a millage tax based on property evaluation.
14. Developer's estimated ultimate cost of sewers and treatment when the remaining two sections with 115 more houses are built.
15. Trunk sewers only.
16. Cost of shallow trunk intercepting sewers only was borne by land developer. Cost of street collector system and laterals was borne by the several house contractors building in the area of the over-all land development.
17. Power only.
18. Developer also receives $125 per month from the connected school.
19. None had been established.
20. Treatment plant only.
21. Had not been determined.
22. Includes cost of house laterals.
23. County Water Control and Improvement District formed on petition of developers.

APPENDIX B

TABLE 4

TYPE OF SEWAGE TREATMENT FACILITY FOR SELECTED SUBDIVISIONS

INSTALLATION	SEPTIC TANK	IMHOFF TANK	PRIMARY CLARIFIER	TRICKLING FILTER	ACTIVATED SLUDGE	CONTACT AERATOR	STABILIZATION BASIN	PROPRIETARY EQUIPMENT	SECONDARY CLARIFIER	SAND FILTER	SEPARATE SLUDGE DIGESTOR	SLUDGE DRYING BED	CHLORINATOR	DISTANCE FROM HOUSES
														Feet
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1	x			x										
2		x												
3			x		x					x				
4			x		x				x		x	x	x	
5			x	x					x		x	x	x	
6		x		x					x		x	x	x	
7		x							x				x	
8		x								x				
9			x	x								x	x	
10			x	x					x				x	300
11			x	*x					x		x	x	x	400
12			x	*x					x		x	x		500
13		x							x		x	x	x	500
14			x		x							x	x	200
15	Served by Installation 17								x		x	x		500
16			x		x									
17			x		x				x		x	x		500
18	Served by Installation 17								x		x	x		500
19			x			x		x	x		x	x		500
20			x		x				x		x	x		500
21			x			x		x	x		x	x	x	200
22			x			x		x	x		x	x	x	300
23		x		x					x			x		500
24			x		x				x		x	x		1000
25	Served by Installation 24													
26			x			x		x	x		x	x	x	500

TABLE 4 — (Continued)

Column (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
27			x		x									
28	Served by Installation 24								x		x	x		500
29		x		x										
30				x					x			x		300
31		x		x				x						2000
32				x					x			x		5000
33	x							x						100
34					x					x				200
35					x			x						400
36	Served by Municipality							x						1300
37							x							
38			x	x					x			x		500
39		x		x					x			x		300
40			x	x		x		x						600
41			x	x					x		x	x		5500
42			x	*x			x				x	x		2700
43			x		x				x		x	x	x	300
44			x	x				x	x		x	x	x	500
45							x							1000
46			x	*x					x		x			500
47							x							1000
48			x	*x			x		x					4000
49					x			x			x	x	x	1000
50		x		*x					x					1000
51			x	*x				x				x	x	500
52					x				x		x	x	x	1000
53			x		x			x						500
54		x		x					x		x	x		2000
55						x			x				x	500
56		x		x				x			x	x		500
57			x	x					x					500
58		x		*x		x		x	x		x	x	x	500
59		x		*x					x			x	x	500
60								x	x			x	x	500
61						x		x						500
						x		x						75

* This installation employed high-rate trickling filter.

APPENDIX C

March 1, 1959

STATE WATER POLLUTION CONTROL AGENCIES

STATE	AGENCY AND ADDRESS	OFFICIAL AND TITLE
ALABAMA	Water Improvement Commission State Office Building Mongomery 4, Alabama	A. N. Beck Technical Secretary
ALASKA	Water Pollution Control Board Alaska Office Building Juneau, Alaska	H. V. Gibson, M.D. Executive Secretary
ARIZONA	State Department of Health Phoenix, Arizona	Clarence G. Salsbury, M.D. Commissioner of Public Health
ARKANSAS	State Water Pollution Control Commission 921 West Markham Little Rock, Arkansas	Glen T. Kellogg Technical Secretary
CALIFORNIA	State Water Pollution Control Board Room 316 1227 "O" Street Sacramento 14, California	Paul Bonderson Executive Officer
COLORADO	State Department of Public Health State Office Building Denver 2, Colorado	R. L. Cleere, M.D. Executive Director
CONNECTICUT	Water Resources Commission State Office Building 165 Capitol Avenue Hartford 15, Connecticut	William S. Wise Director
DELAWARE	State Water Pollution Commission State House Annex Governor's Avenue & Division St. Dover, Delaware	A. Joel Kaplovsky Director
DISTRICT OF COLUMBIA	District of Columbia Department of Public Health Washington 1, D. C.	William H. Cary, Jr. Chief, Food and Public Health and Engineering
FLORIDA	State Board of Health 1217 Pearl Street Jacksonville 1, Florida	Wilson T. Sowder, M.D. State Health Officer
GEORGIA	Georgia Department of Public Health State Office Building Atlanta 3, Georgia	T. F. Sellers, M.D. Director
HAWAII	Territorial Board of Health Kapuaiwa Building P. O. Box 3378 Honolulu 1, Hawaii	Richard K. D. Lee, M.D. President
IDAHO	Idaho Department of Health State House Boise, Idaho	Terrill O. Carver, M.D. Administrator of Health
ILLINOIS	State Santary Water Board State Office Building 400 South Spring Street Springfield, Illinois	C. W. Klassen Technical Secretary
INDIANA	Stream Pollution Control Board Department of Health 1330 West Michigan Street Indianapolis 7, Indiana	B. A. Poole Technical Secretary
IOWA	State Department of Health State Office Building Des Moines 19, Iowa	E. G. Zimmerer, M.D. State Commissioner of Health
KANSAS	State Board of Health Topeka, Kansas	Geoffrey M. Martin, M.D. Executive Secretary

STATE WATER POLLUTION CONTROL AGENCIES — (Continued)

STATE	AGENCY AND ADDRESS	OFFICIAL AND TITLE
KENTUCKY	Water Pollution Control Commission 620 South 3rd Street Louisville 2, Kentucky	Louis F. Birkel Executive Director
LOUISIANA	Stream Control Commission Box 9055, University Station Baton Rouge 3, Louisiana	Kenneth E. Biglane Executive Secretary
MAINE	Water Improvement Commission c/o Department of Health and Welfare State House Augusta, Maine	Dean H. Fisher, M.D. Secretary
MARYLAND	State Department of Health 2411 North Charles Street Baltimore 18, Maryland	Robert M. Brown, Chief Bureau of Environmental Hygiene
MASSACHUSETTS	Massachusetts Department of Public Health 546 State House Boston 33, Massachusetts	Alfred L. Frechette, M.D. Commissioner of Public Health
MICHIGAN	Water Resources Commission Station B 300 E. Michigan Lansing 13, Michigan	Milton P. Adams Executive Secretary
MINNESOTA	Water Pollution Control Commission State Department of Health Bldg. Campus, University of Minnesota Minneapolis 4, Minnesota	R. H. Barr, M.D. Secretary
MISSISSIPPI	State Board of Health Old Capitol Building P. O. Box 1700 Jackson 5, Mississippi	A. L. Gray, M.D. Executive Officer and Secretary
MISSOURI	State Water Pollution Board Division of Health Department of Public Health and Welfare Jefferson City, Missouri	J. K. Smith Executive Secretary
MONTANA	State Board of Health Laboratory Building Helena, Montana	G. D. Carlyle Thompson, M.D. Acting Executive Officer
NEBRASKA	Department of Health State Capitol Building Lincoln 9, Nebraska	E. A. Rogers, M.D. Director of Health
NEVADA	State Department of Health 755 Ryland Street Reno, Nevada	D. J. Hurley, M.D. Acting State Health Officer
NEW HAMPSHIRE	Water Pollution Commission 61 South Spring Street Concord, New Hampshire	William A. Healy Technical Secretary
NEW JERSEY	State Department of Health Trenton 25 New Jersey	Daniel Bergsma, M.D. State Commissioner of Health
NEW MEXICO	State Department of Public Health Santa Fe, New Mexico	S. J. Leland, M.D. Director of Public Health
NEW YORK	State Department of Health 84 Holland Avenue Albany 8, New York	Herman E. Hilleboe, M.D. Commissioner of Health
NORTH CAROLINA	State Stream Sanitation Committee North McDowell Street Raleigh, North Carolina	Earle C. Hubbard Secretary
NORTH DAKOTA	State Department of Health Capitol Building Bismarck, North Dakota	W. Van Heuvelen Executive Officer

STATE WATER POLLUTION CONTROL AGENCIES — (Continued)

STATE	AGENCY AND ADDRESS	OFFICIAL AND TITLE
OHIO	Water Pollution Control Board 101 North High Street Columbus 15, Ohio	Ralph E. Dwork, M.D. Chairman
OKLAHOMA	State Department of Health 3400 North Eastern Oklahoma City 5, Oklahoma	G. F. Mathews, M.D. Commissioner of Health
OREGON	State Board of Health 1400 S. W. 5th Avenue Portland 1, Oregon	M. M. Erickson, M.D. State Health Officer
PENNSYLVANIA	Sanitary Water Board Pennsylvania Department of Health State Capitol Health and Welfare Building Harrisburg, Pennsylvania	Charles L. Wilbar, Jr., M.D. Chairman
PUERTO RICO	Department of Health Ponce de Leon Avenue San Juan 18, Puerto Rico	Guillermo Arbona, M.D. Secretary of Health
RHODE ISLAND	Department of Health State Office Building Providence 2, Rhode Island	Jeremiah A. Dailey, M.D. Director of Health
SOUTH CAROLINA	State Water Pollution Control Authority Room 417, Wade Hampton Building Columbia 1, South Carolina	W. T. Linton Executive Director
SOUTH DAKOTA	Committee on Water Pollution State Capitol Pierre, South Dakota	Charles E. Carl Secretary and Executive Officer
TENNESSEE	Stream Pollution Control Board Sixth Avenue, North Nashville 3, Tennessee	S. Leary Jones Director
TEXAS	State Department of Health 410 E. Fifth Street Austin 14, Texas	Henry A. Holle M.D. Commissioner of Health
UTAH	State Water Pollution Control Board 122-A State Capitol Building Salt Lake City 1, Utah	Lynn M. Thatcher Executive Secretary
VERMONT	State Water Conservation Board State Office Building Montpelier, Vermont	R. H. Thieme Commiissioner
VIRGINIA	State Water Control Board 415 West Franklin Street Richmond 20, Virginia	A. H. Paesselr Executive Secretary
VIRGIN ISLANDS	Virgin Islands Department of Health Charlotte Amalie St. Thomas, Virgin Islands	Eric L. O'Neal, M.D. Commissioner of Health
WASHINGTON	Washington Pollution Control Commission 224 Old Capitol Building Olympia, Washington	Arthur Garton Director
WEST VIRGINIA	State Water Commission 1709-A Washington Street, East Charleston 1, West Virginia	Bern Wright Director
WISCONSIN	State Committee on Water Pollution State Office Building Madison 2, Wisconsin	T. F. Wisniewski Director
WYOMING	State Department of Public Health State Office Building Cheyenne, Wyoming	Director of Public Health

INTERSTATE WATER POLLUTION CONTROL AGENCIES

COOPERATING STATES	AGENCY AND ADDRESS	OFFICIAL AND TITLE
ILLINOIS MISSOURI	Bi-State Development Agency 915 Olive Street St. Louis 1, Missouri	Mr. Leif J. Sverdrup Chairman
DELAWARE NEW JERSEY NEW YORK PENNSYLVANIA	Interstate Commission on the Delaware River Basin Suburban Station Building Philadelphia 3, Pennsylvania	Mr. James H. Allen Executive Secretary
DISTRICT OF COLUMBIA MARYLAND PENNSYLVANIA VIRGINIA WEST VIRGINIA	Interstate Commission on the Potomac River Basin Transportation Building 815 17th Street, N. W. Washington 6, D. C.	Mr. Ellis S. Tisdale Director
CONNECTICUT NEW JERSEY NEW YORK	Interstate Sanitation Commission 10 Columbus Circle New York 19, New York	Mr. Thomas R. Glenn, Jr. Director and Chief Engineer
CALIFORNIA OREGON	Klamath River Compact Commission P. O. Box 388 Sacramento 5, California	Mr. R. B. Bond Executive Secretary
CONNECTICUT MAINE MASSACHUSETTS NEW HAMPSHIRE NEW YORK RHODE ISLAND VERMONT	New England Interstate Water Pollution Control Commission 73 Tremont Street Boston 8, Massachusetts	Mr. Joseph C. Knox Secretary
ILLINOIS INDIANA KENTUCKY OHIO PENNSYLVANIA NEW YORK VIRGINIA WEST VIRGINIA	Ohio River Valley Water Sanitation Commission 414 Walnut Street Cincinnati 2, Ohio	Mr. Edward J. Cleary Executive Director and Chief Engineer